1. Introduction

The Washington State Department of Natural Resources (DNR) manages more than 5 million acres of state land. Some of those lands are uplands within the range of the Canada lynx (*Lynx canadensis*) (Figure 1), a native cat that is listed as threatened with extinction—both in the state of Washington and under the federal Endangered Species Act.

Lynx habitat is forested, and most DNR-managed forests are managed for sustainable forest management to provide income for various state trust beneficiaries (public schools, state universities, counties and other public institutions). Forest management activities in Washington State are regulated by the state's Forest Practices rules, and DNR's forest management must comply with those rules.

This modified Lynx Habitat Management Plan (the 2006 Lynx Plan) is developed in response to the federal listing of the species (USFWS 2000) and revises the 1996 DNR Lynx Habitat Management Plan (WDNR 1996a) that had been developed in response to the state listing. This plan guides DNR in creating and preserving quality lynx habitat through its forest management activities. It allows DNR to meet state and federal requirements for protecting the lynx, while at the same time providing revenue through timber production, as well as meeting its other land management obligations (i.e. recreation).

This chapter provides historical and management context and basic information about the Canada lynx natural history and distribution. The following chapters define categories of lynx habitat, outline DNR's implementation of the plan, and provide specific guidelines and provisions for monitoring and evaluation. A report on the implementation monitoring conducted for the period 1996-2004, in accordance with the 1996 Lynx Plan commitment, is presented in Appendix 1, and a report on the effectiveness monitoring conducted from 1997 through 2002 is presented in Appendix 2.

1.1 Conservation of Lynx in Washington

The Canada lynx became a Washington State Candidate for listing in 1991 (Washington Department of Wildlife Policy 4802). In 1993, the Washington State Wildlife Commission listed the Canada lynx as threatened in the state of Washington. In response to the listing and at the recommendation of the Washington Forest Practices Board (February 1994), DNR developed a Lynx Habitat Management Plan (WDNR 1996a). This "special wildlife management plan" (WAC-222-16-080 [2]) was a substitute for a species-specific critical habitat designation required by the Forest Practices rule (i.e. WAC-222-16-080 [1]) that would otherwise have been developed in response to the listing. The Washington Department of Fish and Wildlife (WDFW) coordinated and

approved DNR's Lynx Plan, along with plans from the two other major non-federal landowners within primary lynx range (Boise Cascade, Inc. and Stimson Lumber Co.).

The U.S. Fish & Wildlife Service (USFWS) listed Canada lynx as threatened under the Endangered Species Act in the 48 contiguous states, effective April 23, 2000 (USFWS 2000). WDFW developed a Lynx Recovery Plan for the State of Washington in 2001 (Stinson 2001).

In response to the federal listing, DNR worked with USFWS to modify the 1996 Lynx Plan to avoid the incidental take of lynx. In 2002 the USFWS sent DNR a letter of agreement acknowledging that the department's proposed modifications of the 1996 Lynx Plan are not likely to allow incidental take of lynx (USFWS 2002). The letter is referred to in this document as the "take avoidance" letter.

DNR is committed to following the Lynx Plan until the lynx is de-listed, or until 2076 (80 years after the approval of the 1996 Lynx Plan), which ever is shorter. The plan will be updated as more is learned about lynx habitat relationships and management strategies, at least as frequently as every five years hereafter.

DNR's internal policies encourage consideration of lynx habitat on land managed by DNR. Specifically, Forest Resource Plan Policies 20, 22, and 23 (WDNR 1992) direct DNR to:

- participate in efforts to recover and restore endangered and threatened species,
- provide upland wildlife habitat, and
- establish Riparian Management Zones.

DNR will contribute to the future of Washington's lynx population by improving habitat conditions and lessening probabilities for adverse effects on the habitat it manages within the legal obligations specified in the Forest Resource Plan (WDNR 1992).

1.2 Changes to the 1996 Lynx Plan

This 2006 revision of the 1996 Lynx Plan incorporates the take avoidance modifications as well as the new scientific information on Canada lynx and its major prey, the snowshoe hare (*Lepus amercanus*). It also incorporates the results from the implementation and effectiveness monitoring conducted after the 1996 Lynx Plan was adopted (Appendices 1 and 2) and the land transfers conducted since 1996.

The changes to the 1996 Lynx Plan are summarized below:

1) Extension of the area managed for Lynx. The 2006 Lynx Plan will cover approximately 126,212 acres, an increase of 1,177 acres, which is in accordance with the revised lynx management zones (LMZ) and lynx analysis units (LAU) identified by Washington Department of Fish and Wildlife in the Lynx Recovery Plan (Stinson, 2001).

2) Seasonal timber harvest restrictions in all suitable denning habitat from May 1 – July 31.

3) No increases in designated or groomed over-the-snow routes or snowmobile play areas.

4) Delayed pre-commercial thinning until self-pruning processes have excluded most live lower limbs within 2 feet of the average snow pack level, unless the thinning activities are part of an experimental design approved by USFWS.

5) No conversion of more than 15 percent of forested lynx habitat to a temporary non-lynx habitat condition within a 10-year period within any individual LAU. This applies to LAUs where DNR manages more than 20 percent of the LAU (Little Pend Oreille block and Loomis State Forest).

6) Within the Little Pend Oreille block (LPO) and Loomis State Forest, no conversion of more than 5 percent of the lynx habitat within a LAU to the minimum requirements for travel habitat (180 trees/acre) in a 10-year period.

7) Lynx forage habitat is defined using the horizontal cover above average snow level. A young timber stand qualifies as forage habitat when it has no more than four zero scores (no cover) measured in 40 readings (four readings taken at each of the 10 sampling points of a transect, within the 1.5-2.0 m range of a vegetation profile board viewed from 45 feet (15 m) from four cardinal directions).

8) Implementation of the Lynx Plan in accordance with the existing DNR management plans for the Loomis State Forest. Much of the land that DNR manages within the range of the lynx is part of the Loomis State Forest (See Figure 2). Several Loomis-specific planning activities have occurred since the 1996 plan was first implemented.

   The Loomis Natural Resource Conservation Area (NRCA) was established in the Loomis State Forest in January 2000. The parcels transferred into conservation status (24,677 acres) are managed under the laws covering Natural Resource Conservation Areas (NRCA) and the Loomis NRCA Management Plan (WDNR 2003). The management goals of the NRCA management plan are to maintain the parcels in the most natural condition possible, to protect examples of native ecosystems, to protect habitat for listed species, and to comply with the ecosystem standards for state owned agricultural and grazing lands.

   The remaining 110,000 acres of the Loomis State Forest are managed under the Loomis State Forest Landscape Plan (WDNR 1996b). The Loomis Landscape Plan is being updated to reflect the changes in conservation status of part of the area and the results from the waterershed analyses conducted in the South Fork Toats Coulee and Sinlahekin Watershed Analysis Units (WAU).

1.3 Lynx Natural History

DESCRIPTION OF THE SPECIES

Canada lynx (hereafter referred to as lynx) are medium-sized cats, smaller than cougars but slightly larger than bobcats. Mature individuals weigh 15-30 pounds (6.8-13.6 kg), and their average length is 33.5 inches (85 cm) for males and 32 inches (82 cm) for females. Lynx are characterized by a short and black-tipped tail, tufted ears, facial ruff, elongated hind legs, and large paws. These large paws enable lynx to travel through boreal forests in search of their favored prey – the snowshoe hare - in habitats often avoided by other predators, whose movements are more inhibited by deep snow. For example, in the southern edge of the lynx geographic range, bobcats, cougars, and coyotes spend the winter on south-southwest aspects, approximately 300-400 feet (984-1312 m) lower than lynx (Koehler 1990a, Koehler and Hornocker 1991).

FORAGING

Lynx are perhaps best known for their unique association with a single prey item - the snowshoe hare. Ecologists have focused on this predator-prey relationship since it was popularized in the 1940's (e.g., Elton and Nicholson 1942), developing a large quantity of literature and inspiring many theories (Keith 1963; Keith et al. 1984; Krebs et al. 1991, 1995; Sinclair et al. 1993). Nearly all the lynx literature concludes that hares rank as the main prey of lynx in all seasons, although snow-free season samples are relatively rare. Hares are found in scats with frequencies of 35 percent (during a low in hare abundance Brand and Keith 1979) to 100 percent (Kesterson 1988) and volumes in stomach and intestine samples of 41 percent (Saunders 1963a) to 100 percent (Brand et al. 1976). The study by Von Kienast (2003) conducted on the Okanogan Plateau (Washington) recorded snowshoe hare in 85-90 pecent of lynx scats. Also, the loss of body fat by lynx during periods of low hare density indicates that they might not be able to consume enough alternative prey (e.g., grouse, squirrels, and carrion) to meet their energy requirements (Brand and Keith 1979).

Despite the strong association of lynx to snowshoe hare, there is also clear evidence that lynx take advantage of other prey opportunities, especially when hares are at low densities and during the summer. The alternative prey consists of red squirrels, mice, voles, ground squirrels, grouse, ptarmigan, etc. (Tumilson 1987, Hatler 1988, Butts 1992, Koehler and Aubry 1994, Ruggiero et al. 2000, Stinson 2001). High frequencies of red squirrels in lynx diets have been reported from Washington (Koehler 1990a, Von Kienast 2003), Yukon (O'Donoghue et al. 1998), and Alaska (Staples 1995). Lynx consumption of caribou, Dall sheep, and red foxes was reviewed by Stephenson et al. (1991). One of the most famous examples of lynx as predators on non-hare prey is from Newfoundland, where lynx had a dramatic and publicized effect on caribou herds (Bergerud 1971, 1983). Examples of seasonal opportunism include a more diverse diet in summer, when more diverse prey are available (Saunders 1963a, van Zyll de Jong 1966, Brand et al. 1976, Parker et al. 1983, Staples 1995).

Nonetheless, the density of lynx populations oscillates only with the density of snowshoe hare through changes in reproduction and survival patterns, especially through reproductive success of yearlings and survival of kittens (see Koehler and Aubry 1994 for a review; Mowat 1993, O'Connor 1984). Lynx reproductive success and survival shows the strongest correlation with winter/early spring snowshoe hare abundance (e.g. Nellis et

al. 1972, Brand and Keith 1979, Parker et al. 1983, O'Connor 1984, Mowat 1993, Poole 1994). Winter is likely the constraining season in hare populations (Walski and Mautz 1977, Krebs et al. 1986, Krebs et al. 1991) due to the high metabolic requirements to maintain a constant, warm body temperature during extreme cold temperatures, combined with a relative lack of browse. Periods of unusually cold weather have been correlated with increased mortality rates in both hare (Meslow and Keith 1971, Pease et al. 1979) and lynx (Poole 1994).

Because of the documented strong dependence of lynx on a single prey item (snowshoe hare), the USFWS concluded that, "the key to the presence of lynx populations is adequate snowshoe hare populations" (USFWS 2003).

DISTRIBUTION

The range of the Canada lynx encompasses the Canadian and Hudsonian life zones (Ingles 1965) of boreal North America (Figure 1). Nearly all of this area lies within Canada and Alaska, with only about 6 percent of the total species range in the contiguous United States. Lynx range in Washington State represents approximately 0.5 percent of the total area occupied by Canada lynx. However, Washington may support a significant proportion of the resident populations of lynx in the contiguous United States (Brittell et al. 1989). Of the 14 states where lynx formerly resided, breeding lynx have recently been detected in Washington (Brittell et al. 1989, Koehler 1990a), Montana (Brainerd 1985, Giddings 1994), Maine (Vashon et al. 2003), Wyoming (Squires and Laurion 2000), and Minnesota (Star Tribune 3/7/2003). Introduced lynx are now breeding in Colorado as well (Colorado Division of Wildlife website 2005).

Historical evidence suggests that in Washington, lynx were found primarily in high-elevation forests of northcentral and northeast Washington, including Okanogan, Chelan, Ferry, Stevens and Pend Oreille counties (Stinson 2001). Although 82 percent of 72 museum records of lynx are from these five counties, lynx presence was also recorded in the Blue Mountains of southeastern Washington and the southern Cascades (Dalquest 1948, Stinson 2001).

Currently, primary lynx habitat identified in the Lynx Recovery Plan for Washington State (Stinson, 2001) includes six Lynx Management Zones (LMZ) (Figure 2). They are characterized by high elevation, coniferous forests, and accumulation of deep snow. The LMZs do not encompass all areas potentially used by lynx, but habitat management in these zones is expected to hold the greatest promise for supporting lynx populations. Recent survey efforts (1995-2001) indicated that lynx remain in four LMZs (Okanogan, Kettle Range, Little Pend Oreille, and Salmo Priest) and are breeding in the Okanogan LMZ (Stinson 2001).

DNR manages 4 percent of the primary lynx habitat in Washington, approximately 126,212 out of 3,198,238 acres of designated lynx habitat in Washington. DNR manages some land in each of the six LMZs (Figure 2). Most of the lynx habitat managed by DNR (77 percent, approximately 97,124 acres) is within the Okanogan LMZ. This comprises 20-30 percent of the area occupied by lynx during the mid-1980's lynx studies in northcentral Washington (Brittell et al. 1989, Koehler 1990a).

Figure 1. Distribution of the Canada Lynx (*Lynx canadensis*)

Modified from Quinn and Parker 1987

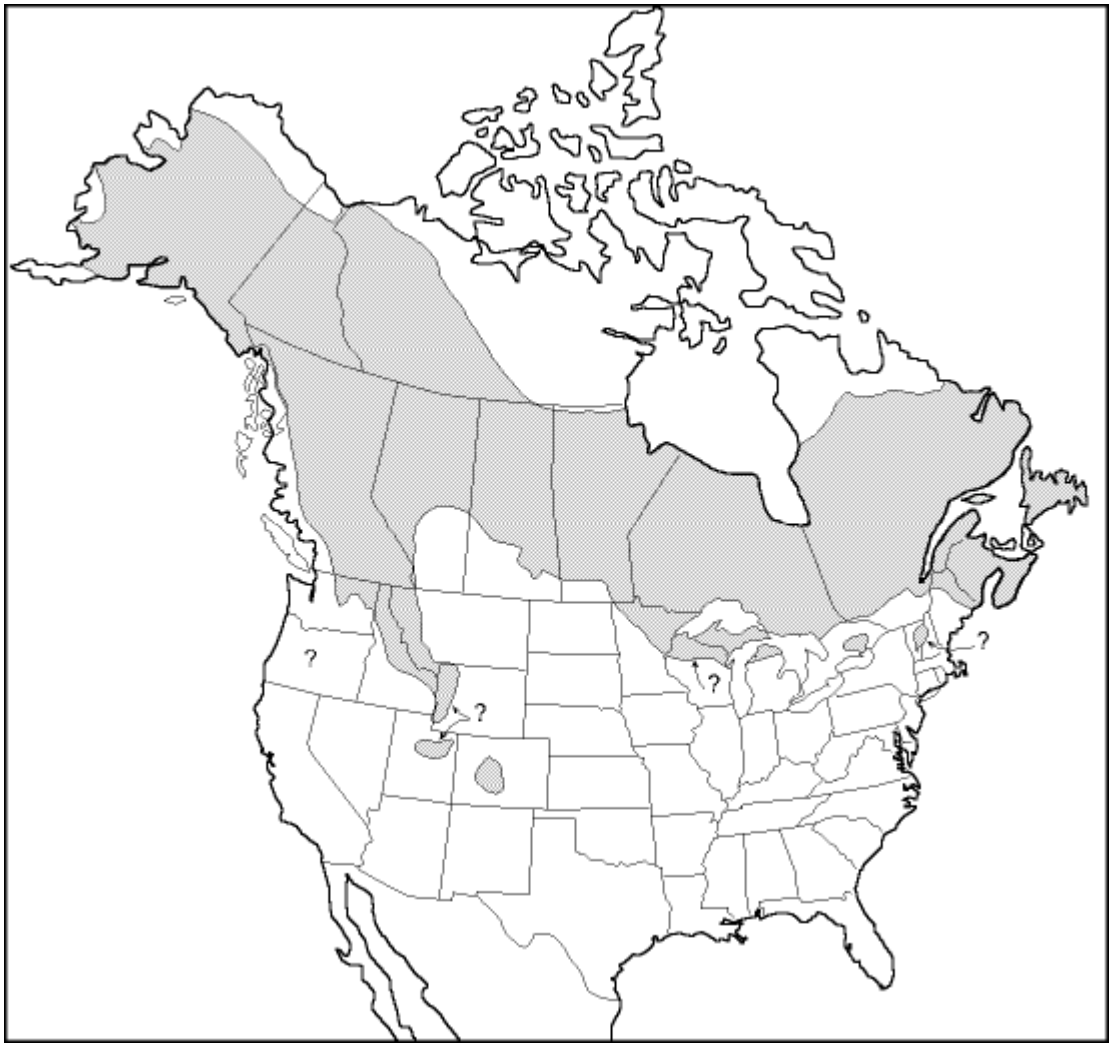
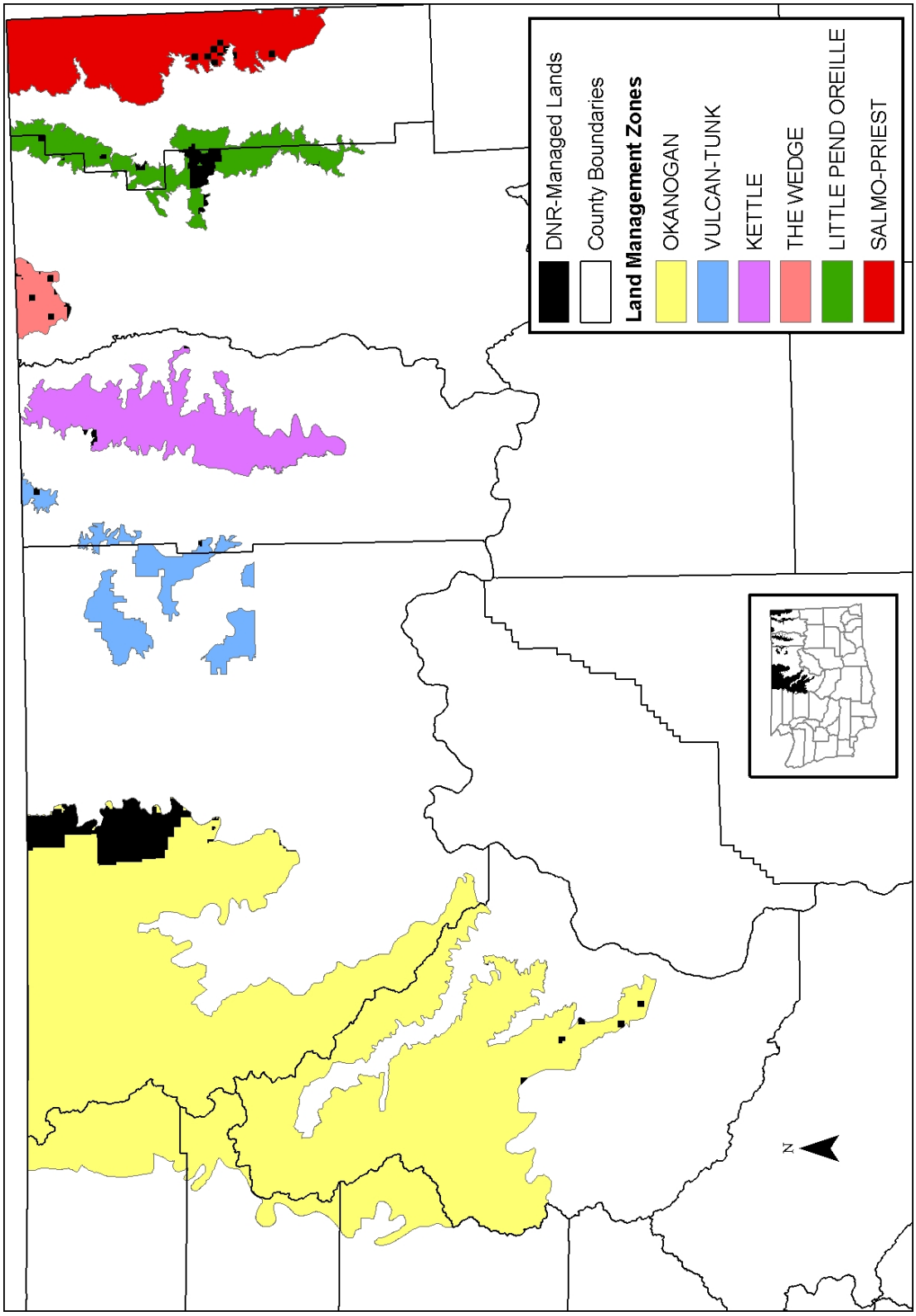


Figure 2. Lynx Management Zones in Washington

Modified from Stinson 2001



HABITAT RELATIONSHIPS

One of the least studied aspects of lynx ecology is lynx habitat relationships. Most lynx research has addressed population dynamics in relation to fluctuating prey availability rather than habitat associations.

Lynx avoid open and sparsely forested areas. The disassociation between lynx and open areas (meadows, frozen lakes, rivers, etc.) is a well-recognized and reported relationship (Koehler et al. 1979, Parker et al. 1983, Murray et al. 1994, Poole 1994, Von Kienast 2003)[1]. When WDW (1993) calculated lynx densities for Washington State, they extrapolated lynx densities from the average lynx density within the Okanogan study area (Brittell et al. 1989, Koehler 1990a) to the acres of suitable habitat within the state, excluding generally avoided habitat types.

Lynx occur in a wide variety of forest types. The most undisputed habitat association is the tie between lynx and mid-successional forests; those resembling a 20-40-year-old forest that has regenerated after a low-to-moderate intensity burn (e.g., 20-30-year-old stands, Thompson et al. 1989). The forests are characterized by high vertical and horizontal vegetative cover as the result of high stem densities, with average tree heights of 7-20 feet (2-6 m) and crown closure of 75-80 percent (e.g., Parker 1981). The scientific literature is nearly unanimous in supporting this relationship, offering examples of lynx establishing nearly their entire home ranges within such habitat, regardless of latitude or season:

- An area actively used by two lynx in Newfoundland almost exactly coincided with the boundary of a 10-20-year-old forest (Saunders 1961).
- 90 percent (n=29) of the relocations of two lynx were within densely stocked stands in Montana (Koehler et al. 1979).
- 87 percent (n=391) of the relocations of 11 lynx were in a 31-year-old burn on the Kenai Peninsula in Alaska (Kesterson 1988).
- Lynx were relocated in regenerating lodgepole pine more than expected ($p<0.001$) in the Yukon (Major 1989).
- Lynx tracks were most abundant in sites logged 20-30 years previous to a study in Ontario (Thompson et al. 1989).
- 98 percent (n=240) of lynx tracks observed on snow tracking surveys in central interior Alaska were located in a 25-year-old burn (Johnson et al. 1995).

[1] "Avoidance" used here implies *general* avoidance. Lynx sometimes do cross open areas (most often <328 feet (100m) wide; Koehler and Brittell 1990; B. Slough, Yukon Dep. Renewable Resour., pers. commun.; Staples 1995) or sun themselves in them (Parker 1981), but most of the time they avoid them (e.g. Halfpenny and Biesiot 1986). For example, lynx crossed a 0. 6-mile (1 km) wide lake in the Yukon, but most often walked around it (G. Mowat, Timberland Consultants Ltd., pers. commun.). In Alaska, 0.8 percent of lynx tracks crossed open habitats despite these habitats covering 20 percent of the study area (Staples 1995). In Northwest Territories, lynx crossed frozen lakes, meadows and rivers (Poole et al. 1996, Poole 1997).

- In Northwest Territories (Poole et al. 1996) lynx were most often relocated in dense coniferous forest (20-60-year old burns) and dense deciduous forests.

Some of the highest lynx densities recorded (50 lynx/100 km^2 or 2 lynx/3mi^2) occurred in approximately 30-year-old burn in the Yukon (Breitenmoser and Haller 1993, Mowat and Slough 1995). In Riding Mountain National Park, Manitoba, 96 percent of lynx tracks occurred where there were hare tracks, and the optimum hare habitat was nearly 30-year-old regenerating jackpine forest (Nylen-Nemetchek 1999). The primary reason for the tight association between lynx and mid-successional forests is that this habitat contains the highest densities of snowshoe hare, the staple prey of lynx.

Lynx are also associated with mature forests[2], but this relationship is not as clearly defined as the one between lynx and mid-successional forests. Sometimes mature forests are used in proportion to their availability (Parker et al. 1983, Brittell et al. 1989, Murray et al. 1994, Von Kienast 2003), sometimes they are preferred (Parker 1981, Major 1989, Koehler 1990a, Staples 1995), and sometimes they are avoided (Parker 1981, Kesterson 1988, Thompson et al. 1989, Staples 1995). When significant use of mature forests by lynx is detected, a commonly cited reason is for denning. However, structure (log piles, rocks, root tangles, shrub thickets) or similarly dense vegetation (e.g. subalpine fir; Slough 1999) rather than forest maturity is the common denominator of known denning areas.

1.4 Conservation Issues

Habitat conservation, lynx fur harvest, and snowshoe hare and lynx population dynamics throughout the range of the lynx became an increasing concern in the late 1960's as decreases in sightings and fur harvests were reported and human populations expanded into remote lynx country.

FUR HARVEST

Humans have been the historical, proximate influence on lynx density throughout most of the lynx's range (Parker et al. 1983, Ward and Krebs 1985; see Koehler and Aubry 1994 for review). Although untrapped lynx populations may undergo dramatic losses from natural mortality following low abundance of hare populations, these changes are compensatory. Evidences suggest that low lynx densities after heavy harvests cannot be compensated even after a period of high snowshoe hare densities: on the Kenai National Wildlife Refuge, the lynx fur harvest of 1973-1974 was 40 times greater than 1966-1967 (Bailey 1981); in Washington, three times as many individuals were trapped in the 1970s (146 animals, from 1969-1978) than in the 1960s (44 animals, from 1960-1969). Many locations reported lower fur harvests in the 1980's compared with the 1970's: Alberta (Todd 1985), Washington (Brittell et al. 1989 and Koehler 1990a), Montana (Hash 1990, Roy 1990), Alaska (Stephenson 1986), Manitoba (McKay 1985), and British Columbia (Hatler 1988). All of the authors referenced above suspected that the declines were at least partially due to over-trapping in the 1970's, when pelt prices were relatively high. The Lynx Management Guidelines of British Columbia (B.C. Ministry of Environment

[2]"Mature forests" in this context refer to forests older than mid-successional forests, a general definition to account for the many ways the term has been presented in the lynx literature.

1990) describe a double peak in 1972-73 and 1973-74—more than 8,500 pelts were sold each year. Sighting records similarly indicated a decline in lynx abundance from 1983 to 1993 (WDW 1993), and lynx presence was confirmed in only 44 of 121 Lynx Analysis Units in Washington surveys between 1995 and 2001 (Stinson 2001).

Since 2000, with the federal protection of lynx in the contiguous United States, direct harvest of lynx is no longer a major threat. However, incidental hunting and trapping mortalities probably still occur (Stinson 2001).

METAPOPULATION[3] DYNAMICS

Many authors recognize Washington and other northern US states as sink areas (areas in which local mortality rate exceeds local reproductive rate and the populations would go extinct without immigration from source areas) for lynx emigrating from Canada during lynx population highs or when snowshoe hare abundance declines (Banfield 1974, Mech 1980, Koehler and Aubry 1994). Lynx metapopulation dynamics has been discussed in length in Ruggiero et al. (2000), Stinson (2001), and McKelvey et al. (2000). Future studies on lynx breeding in northern states, and on large scale habitat change influencing lynx densities in Canada, may find that the northern states are at some times important sources of lynx for Canada. For example, Brittell et al. (1989) documented northerly movements of Washington lynx into British Columbia.

Lynx are capable of traveling extremely long distances (up to 1,100km, Mowat et al. 2000). These travels are reflected in the genetic similarity of geographically dispersed populations (Schwartz et al. 2002, Rueness et al. 2003). However, given that the Rocky Mountains appeared to be a barrier to gene flow within Canada (Rueness et al. 2003), potential contributions from Washington and other southern lynx habitats to Canada populations may be important to the species' survival. Also, the juxtaposition of plant and animal species associated with boreal forests in the northern US affords a unique setting for research on lynx ecology. Ecological, social, and physiological adaptations and habitat preferences may become more apparent as the contrast between preferred versus available habitat increases in southern latitudes.

HABITAT MANAGEMENT

As once-remote lynx habitat becomes developed, mined, and logged, the need to clarify lynx habitat associations and the effects of land management activities on lynx persistence and density has become imperative. The status of lynx may only be effectively ascertained and recovery strategies successful after these relationships are clarified. USFWS (2000) and the Lynx Recovery Plan for Washington State (Stinson 2001) list timber harvest, fire history and suppression, forest roads and recreation, grazing and grass seeding, forest insect epidemics, and highway barriers as factors that may affect the continued existence of lynx. Habitat changes associated with global warming may further influence lynx conservation in Washington State.

[3] Metapopulation is defined as set of local populations within some larger area, where migration from one local population to at least some other patches is typically possible.